1 OF 1

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1.0
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EVALUATION OF GM 1976 PROTOTYPE VEHICLE, A CATALYTIC EXHAUST MANIFOLD SYSTEM

Henry L. Gompf

Environmental Protection Agency
Ann Arbor, Michigan

June 1972

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EVALUATION OF A GM 1976 PROTOTYPE VEHICLE - A CATALYTIC EXHAUST MANIFOLD SYSTEM

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Inhouse

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15. Supplementary Notes

16. Abstracts

A test sequence was conducted on a General Motors prototype utilizing a catalytic exhaust manifold system concept. Due to the consistent success displayed by this system in meeting the required 1976 emission level in the General Motors laboratory, an evaluation program was initiated. The prototype system under evaluation was supplied to EPA installed on a 1972 Chevrolet Belair equipped with an automatic transmission and a 350 cubic inch displacement California engine. Beyond necessary engine modifications, the vehicle was equipped with four major emission controls: 1. A quick heat intake manifold, EFE, to assist in cold start fuel evaporation. 2. A Grace noble metal catalyst for oxidation of hydrocarbon and carbon monoxide. 3. A Gulf noble metal catalyst for reduction of oxides of nitrogen. 4. An air pump and associated valving to supply air for exhaust port oxidation and oxidizing air to the Grace catalyst bed. The GM prototype system was tested three times from a cold start using the 1975 Federal emission test procedure. All three tests were conducted using the recommended dynamometer inertia loading of 5000 pounds. While the prototype vehicle tested showed excellent potential of meeting Federal required levels for 1975-76 a vehicle with minimal deterioration of driveability and fuel economy, it is impossible to assess the full potential of the system without the input durability mileage data. It appears, however, that this prototype system is an excellent candidate for extended mileage evaluation.

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Vehicles
Prototypes
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Tests
Standards
Manifolds
Catalytic converters
Catalysts
Hydrocarbons
Carbon monoxide
Nitrogen oxides
Fuel consumption

17b. Identifiers/Open-Ended Terms

Federal Test Procedure (1975)
GM 1976 Prototype

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19.

Background

As part of the Office of Air Programs continuing effort to keep abreast of potential 1975-76 control technology, a test sequence was conducted on a General Motors prototype utilizing a catalytic exhaust manifold system concept. Data compiled at General Motors Corporation on the test vehicle indicated low mileage average emission data as follows:

Hydrocarbon .25 grams per mile
Carbon Monoxide 2.4 grams per mile
Oxides of Nitrogen .34 grams per mile

Due to the consistent success displayed by this system in meeting the required 1976 emission level in the General Motors laboratory, an evaluation program was initiated by EPA. At the time of the evaluation in the Ann Arbor laboratory, GM had not yet subjected this candidate system to durability evaluation.

System Description

The prototype system under evaluation was supplied to EPA installed on a 1972 Chevrolet Belair equipped with an automatic transmission and a 350 cubic inch displacement California engine. Beyond necessary engine modifications, the vehicle was equipped with four major emission controls.

1. A quick heat intake manifold,EFE, was incorporated to assist in cold start fuel evaporation. Exhaust from both exhaust manifolds was piped transversely through a single plane hot plate in the intake manifold resulting in dual cross flow for warm-up.

2. A Grace noble metal catalyst was employed for oxidation of hydrocarbon and carbon monoxide. The catalyst had a monolith structure.

3. A Gulf noble metal catalyst was employed for reduction of oxides of nitrogen. This catalyst had a monolith structure.

4. An air pump and associated valving was used to supply air for exhaust port oxidation and oxidizing air to the Grace catalyst bed.

The sequence of operation during EPA's evaluation was largely manual. For cold start purposes the choke was manually released within three seconds of vehicle start-up. Initially air injection was directed manually to the exhaust ports during catalyst bed warm-up. After reaching necessary catalyst temperature (approximately 60 seconds) the major portion of the air injection was manually diverted to the oxidizing catalyst for the duration of the testing cycle. Simultaneously the exhaust to the EFE manifold was shut-off. The manual controls utilized could feasibly be replaced with temperature actuated valves after further optimization studies.

Both catalyst beds were neatly packaged together at the rear of each exhaust manifold. Special note should be made of the fact that this system does not employ any exhaust gas recirculation for the control of oxides of nitrogen other than that obtained from valve overlap with the 1972 California camshaft.

A schematic view of the overall engine system is presented in Figure 1 of this report. Figure 2 schematically shows typical valving and a cross section of the catalyst beds. (Note that this figure shows pellatized beds whereas the one tested was monolithic in structure).

Test Procedure

The GM prototype system was tested three times from a cold start using the 1975 Federal emission test procedure. Full details of this procedure are found in the July 2, 1971, Federal Register, Volume 36, Number 128, Part II.

All three tests were conducted using the General Motors recommended dynamometer inertia loading of 5000 pounds. Test fuel was Indolene Clear (an available lead free standard fuel).

In addition, one hot start 1972 split-bag procedure was conducted at an inertia weight of 4000 pounds to indicate, if possible, major effects of vehicle size on emissions with this type of system.

Emission Test Results

Table 1 shows the results of the three individual cold start tests. As can be seen the hydrocarbon and carbon monoxide levels were lower than those reported by GM in their previous testing. The oxides of nitrogen levels measured in the EPA evaluation were higher than GM's figures. In the General Motor's testing the vehicle consistently met 1976 required levels, while the EPA testing showed that the oxides of nitrogen exceeded allowable levels. The vehicle did consistently meet maximum allowable emission levels for 1975 vehicles.

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Table 2 compares the hot start 1972 procedure emissions of the 5000 pound test weight with the 4000 pound results. Significant in this table is the 12% reduction in oxides of nitrogen at the 4000 pound weight.

Fuel consumption during the three cold start tests was analytically calculated. An average fuel consumption of 9.9 miles per gallon was reported during EPA tests compared to 9.4 miles per gallon reported by GM.

While no quantitative analysis of the vehicle driveability was made, a report from the test driver and that from another EPA evaluator both reported excellent driveability.

Conclusions

Based on discussions with General Motors engineers differences between EPA emission results and those previously reported by GM were probably due to an interceding vehicle tear-down and build-up immediately prior to delivery to the EPA laboratory.

While the prototype vehicle tested showed excellent potential of meeting Federal required levels for 1975-76 a vehicle with minimal deterioration of driveability and fuel economy, it is impossible to assess the full potential of the system without the input of durability mileage data. It appears, however, that this prototype system is an excellent candidate for extended mileage evaluation.

Due to the characteristics of catalytic-based systems parallel analyses for ammonia, aldehyde and particulate content of the exhaust are desirable to assure overall compliance with light duty motor vehicle goals.

Table 1

1975 FTP Emission Results
(All results in grams per mile at 5000 pounds)

Date	HC	CO		CO_2	NOx
		High Range	Low Range		
*6-5-72	0.26	1.4	1.6	891.8	0.47
6-6-72	0.21	1.8	1.8	891.8	0.45
6-7-72	0.16	1.1	---	895.7	0.49
EPA Average	0.21	1.4	1.7	893.1	0.47
**GM Average	0.25	---	2.4	---	0.34
***GM Average	0.20	---	1.1	835.9	0.44

*Note: After the test on 6-5-72 an orifice change controlling secondary air was performed. No obviously apparent effect resulted.

**GM data collected prior to engine tear-down, rebuild, and subsequent delivery to EPA.

***GM data collected in one test immediately prior to delivery to EPA and immediately following the return of the vehicle to GM.

Table 2

Hot Start 1972 FTP Emission Results
(All results in grams per mile)

Test Inertia Weight	Date	HC	CO	CO_2	NOx
5000 #	6-5-72	0.11	0.5	869.6	0.31
5000 #	6-6-72	0.13	1.3	874.4	0.34
5000 #	6-7-72	0.09	0.5	877.1	0.35
Average at 5000 #		0.11	0.8	873.7	0.33
4000 #	6-7-72	0.18	0.6	800.9	0.29
% Change from 5000 #		64%*	25%**	8%**	12%**

* increase
** decrease

CATALYTIC EXHAUST MANIFOLD SYSTEM

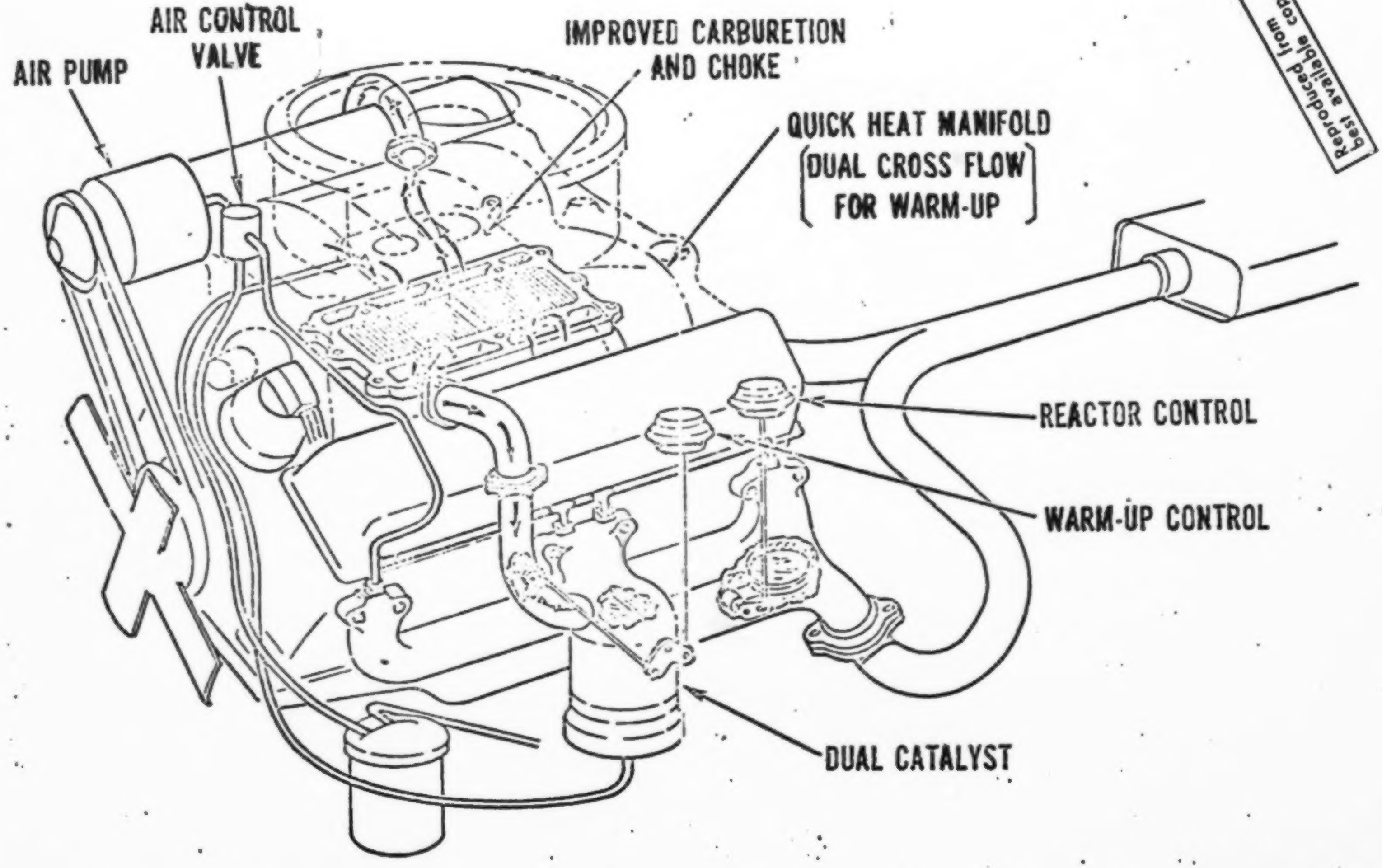
AIR PUMP
AIR CONTROL VALVE
IMPROVED CARBURETION AND CHOKE
QUICK HEAT MANIFOLD (DUAL CROSS FLOW FOR WARM-UP)
REACTOR CONTROL
WARM-UP CONTROL
DUAL CATALYST

Figure 1

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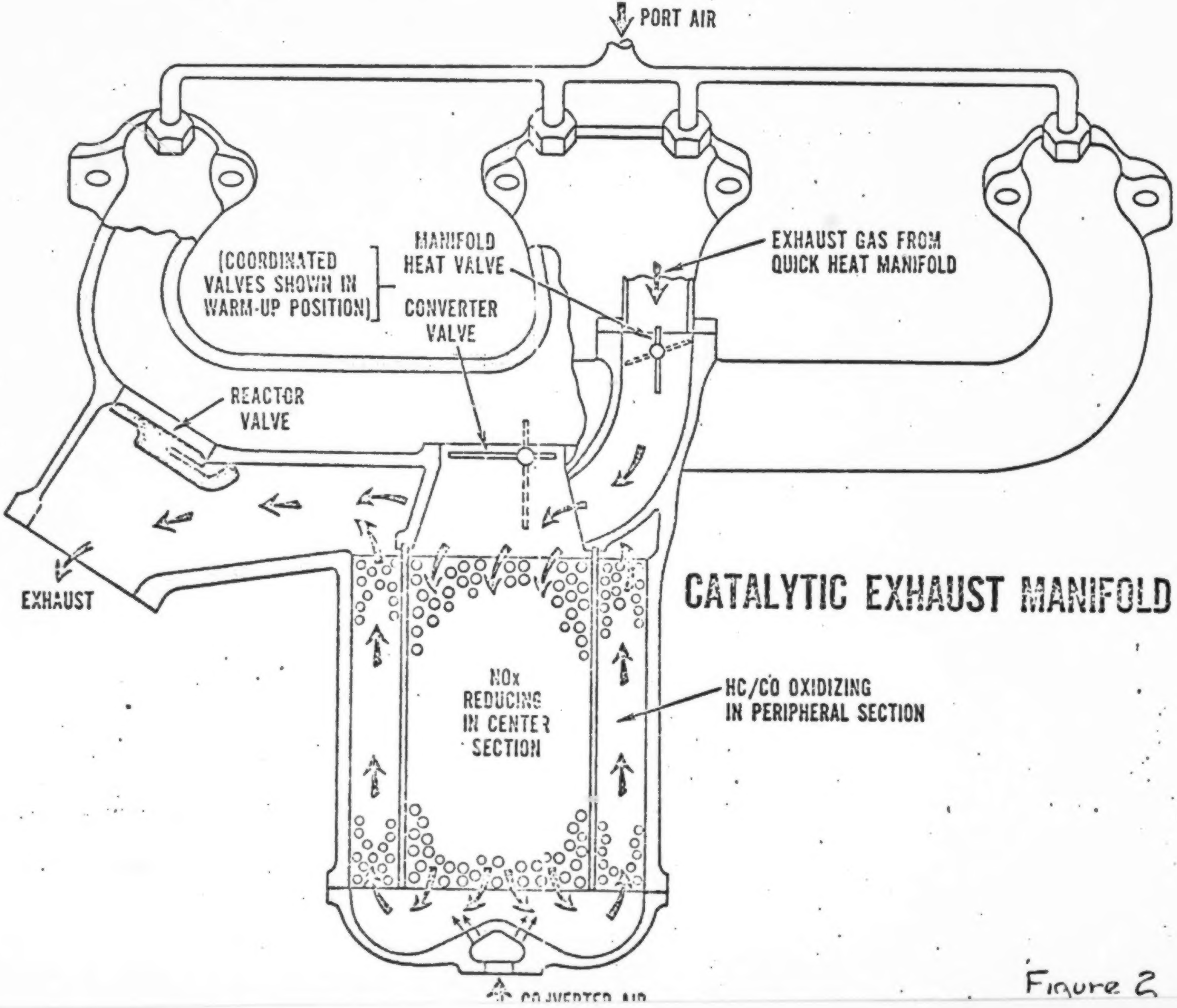
PORT AIR
(COORDINATED VALVES SHOWN IN WARM-UP POSITION)
MANIFOLD HEAT VALVE
CONVERTER VALVE
EXHAUST GAS FROM QUICK HEAT MANIFOLD
REACTOR VALVE
EXHAUST
NOx REDUCING IN CENTER SECTION
HC/CO OXIDIZING IN PERIPHERAL SECTION
CONVERTER AIR

CATALYTIC EXHAUST MANIFOLD

Figure 2